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Assessment of Implementation of Artificial Intelligence Tools in Biology Teaching and Learning at Secondary Schools in Ilorin, Nigeria

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Abstract: The rapid evolution of artificial intelligence (AI) technologies provides numerous possibilities for science education, particularly in biology instruction at the secondary level. This study investigated the perceptions of biology teachers regarding AI integration in secondary schools within Ilorin-West Local Government Area, Kwara State, Nigeria. The research employed a descriptive survey design with a sample of 71 biology teachers selected through systematic sampling. Data collection utilized a structured questionnaire focusing on perceived benefits and consequences of AI integration in biology education. The study considered teachers' gender, qualifications, and teaching experience as moderating variables. Results indicated that teachers strongly recognized AI's potential for personalizing learning experiences (Mean = 3.57) and creating interactive biology lessons (Mean = 3.24). However, significant concerns emerged regarding the reduction of traditional teaching roles (Mean = 3.27) and ethical implications of AI implementation (Mean = 3.13). Statistical analyses revealed no significant differences in perceptions based on gender ($t(68) = 1.45$; $p > .05$), qualifications ($t(68) = -0.54$; $p > .05$), or teaching experience ($F(2,67) = 0.04$; $p > .05$). The results indicate a collective understanding among biology teachers regarding AI's educational value, while indicating the need for structured professional development programs to optimize AI integration in biology instruction.

Keywords: Artificial Intelligence; Biology Education; Teacher Perceptions; Secondary Education; Educational Technology.

1. Introduction

Science education, particularly biology, plays a vital role in developing students' scientific literacy and preparing them for an increasingly technology-driven world. The emergence of artificial intelligence (AI) has introduced novel possibilities for enhancing biology education in secondary schools [1]. Traditional teaching methods often struggle to meet the varied learning needs of students, necessitating innovative pedagogical approaches as biology curricula become more complex and diverse [2]. In the Nigerian context, secondary school biology education faces numerous challenges, including resource constraints, large class sizes, and the need to effectively communicate abstract biological concepts [3]. The integration of AI technologies presents potential solutions through personalized learning platforms, virtual laboratories, and intelligent tutoring systems [4]. These tools offer opportunities to transform how biological concepts are taught and learned, potentially improving student engagement and academic outcomes [5].

Recent studies have demonstrated that AI-enhanced biology instruction can significantly impact student learning experiences. Intelligent tutoring systems can provide immediate feedback, track student progress, and adapt content delivery based on individual learning patterns [6]. Virtual laboratories enable students to conduct experiments safely and cost-effectively, while data analytics help teachers identify areas where students need additional support [7]. However, the successful implementation of AI in biology education depends heavily on teachers' attitudes, readiness, and ability to effectively utilize these technologies [8]. Teachers' perceptions and acceptance of AI tools significantly influence their integration into classroom practices [9]. Studies indicate varying levels of teacher preparedness and concerns regarding AI implementation, ranging from technical challenges to pedagogical

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implications [10]. The education system in Ilorin, Nigeria, presents a unique context for studying AI integration in biology education. The region's schools exhibit diverse technological readiness levels and varying access to educational resources [11]. Understanding teachers' perspectives on AI integration becomes crucial for developing effective implementation strategies and professional development programs [12].

This study aims to investigate the perceived benefits and consequences of AI integration among biology teachers in secondary schools within Ilorin-West Local Government Area, Kwara State. This research work provides valuable information about the factors influencing AI adoption in biology education [13]. The findings contribute to the growing body of knowledge on educational technology integration and offer practical implications for educational stakeholders by analyzing teachers' perspectives across different demographics, including gender, qualifications, and teaching experience [14].

2. Materials and Methods

2.1. Study Design

A descriptive survey design was used to investigate biology teachers' perceptions regarding AI integration in secondary schools. The study was conducted between January and March 2024 in Ilorin-West Local Government Area, Kwara State, Nigeria. This region encompasses 26 public and 19 private secondary schools, representing diverse socio-economic and technological environments [15].

2.2. Study Population and Sampling

The study population comprised biology teachers from secondary schools within the study area. A systematic sampling technique was utilized to select 71 participants, ensuring representation from both public (n=37) and private (n=33) schools. The sample size was determined using Krejcie and Morgan's formula with a 95% confidence level [16].

2.3. Questionnaire

Data collection was carried out through a structured questionnaire developed based on extensive literature review and expert consultation. The questionnaire consisted of three primary sections:

2.3.1. Section A: Demographic Information

This section gathered data on participants' gender, teaching experience, educational qualifications, and school type.

2.3.2. Section B: Perceived Benefits of AI Integration

This section contained 15 items assessing teachers' perceptions of AI benefits in biology education using a four-point Likert scale (1-Strongly Disagree to 4-Strongly Agree). Items addressed aspects such as personalized learning, interactive instruction, and assessment capabilities.

2.3.3. Section C: Perceived Consequences of AI Integration

This section comprised 15 items evaluating teachers' views on potential challenges and implications of AI implementation, using the same four-point Likert scale.

2.4. Validation and Reliability

The questionnaire was rigorously validated through expert review by science education specialists from the University of Ilorin. Content validity was established through assessment of item relevance, clarity, and comprehensiveness. The instrument demonstrated high internal consistency with a Cronbach's alpha coefficient of 0.83 [17].

2.5. Data Collection Procedure

Prior to data collection, ethical approval was obtained from the Department of Science Education, Faculty of Education, University of Ilorin Ethics Committee (Approval code: 04.08.2024-19/25PA089). Permission was secured from school administrators, and informed consent was obtained from all participants. The questionnaires were personally administered by the researcher, with a response rate of 100%.

2.6. Statistical Analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 25.0. The statistical analysis of the data included both descriptive and inferential statistical methods. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize demographic characteristics and response patterns. For inferential analysis, independent t-tests were conducted to examine differences in perceptions based on gender and qualifications. Additionally, one-

way Analysis of Variance (ANOVA) was employed to assess variations across teaching experience categories. All hypotheses were tested at a 0.05 significance level.

The independent variables comprised three categories: gender (male/female), teaching experience (categorized as 0-5 years, 6-10 years, and above 10 years), and educational qualification (classified as qualified or less qualified). The dependent variables focused on two primary aspects: the perceived benefits of AI integration and the perceived consequences of AI integration in biology education.

3. Results

3.1. Demographic Characteristics

The study sample consisted of 71 biology teachers from secondary schools in Ilorin-West Local Government Area. Female teachers constituted 70% (n=49) of the participants, while male teachers represented 30% (n=21). Regarding teaching experience, 47.10% (n=33) had 0-5 years of experience, 35.70% (n=25) possessed 6-10 years of experience, and 17.10% (n=12) had more than 10 years of experience. In terms of educational qualifications, 72.80% (n=51) were categorized as less qualified, holding B.Sc. (52.90%, n=37), HND (17.10%, n=12), or NCE (2.90%, n=2) degrees. The qualified category, comprising 27.20% (n=19) of participants, included teachers with B.Sc.(Ed.) (24.30%, n=17) and B.Sc. with PGDE (2.90%, n=2) qualifications.

Table 1. Demographic characteristics of participants (N=71)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Female	49	70.0
	Male	21	30.0
Teaching Experience	0-5 years	33	47.1
	6-10 years	25	35.7
	>10 years	12	17.1
Educational Qualification	Less Qualified:		
	- B.Sc.	37	52.9
	- HND	12	17.1
	- NCE	2	2.9
	Qualified:		
	- B.Sc.(Ed.)	17	24.3
	- B.Sc. + PGDE	2	2.9

3.2. Perceived Benefits of AI Integration

Analysis of teachers' perceptions regarding AI benefits revealed consistently positive attitudes across multiple dimensions. The highest-rated benefit was AI's potential for enhancing personalized learning (3.57 ± 0.69), followed by its capability to create interactive and engaging biology lessons (3.24 ± 0.92). Teachers also strongly endorsed AI's role in providing additional learning resources (3.21 ± 0.88) and supporting collaborative learning through virtual platforms (3.11 ± 0.96).

Table 2. Mean scores and standard deviations of perceived AI benefits

Benefit Category	Mean	SD
Personalized learning enhancement	3.57	0.69
Interactive and engaging lessons	3.24	0.92
Additional learning resources	3.21	0.88
Collaborative learning through virtual platforms	3.11	0.96

3.3. Perceived Consequences of AI Integration

Teachers expressed several concerns regarding AI implementation. The potential reduction in the need for human teachers emerged as the primary concern (3.27 ± 1.05), followed by ethical considerations in educational decision-making (3.13 ± 0.92). Additional concerns included the possible decrease in students' problem-solving abilities (3.07 ± 0.97) and reduced face-to-face interactions (3.07 ± 0.92).

Table 3. Mean scores and standard deviations of perceived AI consequences

Consequence Category	Mean	SD
Reduction in need for human teachers	3.27	1.05
Ethical considerations in decision-making	3.13	0.92
Decrease in problem-solving abilities	3.07	0.97
Reduced face-to-face interactions	3.07	0.92

3.4. Gender-Based Analysis

Statistical analysis revealed no significant difference between male and female teachers' perceived benefits of AI (t(68)=1.45, p>0.05). Male teachers (47.95±6.18) and female teachers (45.75±5.64) demonstrated similar perceptions regarding AI benefits. Similarly, no significant difference was found in perceived consequences between male (45.19±7.77) and female teachers (44.95±5.77; t(68)=0.14, p>0.05).

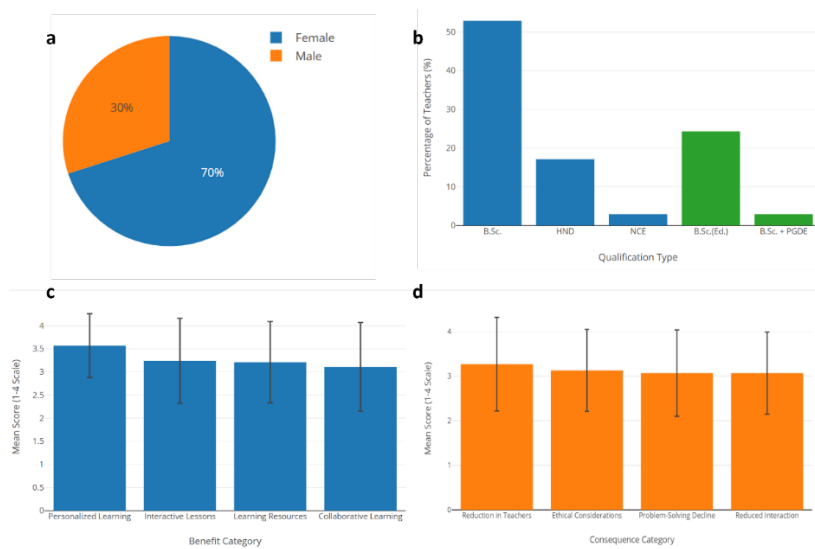**Figure 1. a.** Gender wise distribution of participants **b.** Educational qualifications of the participants **c.** Mean Scores of Perceived AI benefits **d.** Mean Scores of Perceived AI consequences

Table 4. Gender-based comparison of AI perceptions

Perception Category	Gender	Mean	SD	t	p-value
Benefits	Male	47.95	6.18	1.45	>0.05
	Female	45.75	5.64		
Consequences	Male	45.19	7.77	0.14	>0.05
	Female	44.95	5.77		

3.5. Qualification-Based Analysis

Analysis showed no significant difference in perceived benefits between qualified (45.78±6.49) and less qualified teachers (46.64±5.65; t(68)=-0.54, p>0.05). Similarly, perceptions of AI consequences did not differ significantly between qualified (43.47±7.11) and less qualified teachers (45.60±6.05; t(68)=-1.25, p>0.05).

Table 5. Qualification-based comparison of AI perceptions

Perception Category	Qualification	Mean	SD	t	p-value
Benefits	Qualified	45.78	6.49	-0.54	>0.05
	Less Qualified	46.64	5.65		
Consequences	Qualified	43.47	7.11	-1.25	>0.05
	Less Qualified	45.60	6.05		

3.6. Experience-Based Analysis

ANOVA results indicated no significant differences in perceived benefits ($F_{(2,67)}=0.04$, $p>0.05$) or consequences ($F_{(2,67)}=0.21$, $p>0.05$) across experience levels. Teachers with varying years of experience showed consistent perceptions regarding both the benefits and consequences of AI integration in biology education.

4. Discussion

The predominance of female teachers (70%) in the study sample reflects the general gender distribution in science education within the region. Notably, the absence of significant gender-based differences in AI perceptions suggests that gender may not be a determining factor in teachers' acceptance of AI technologies. This finding contrasts with previous studies by Rahman et al. (2023) [18], who reported gender-based variations in technology adoption among secondary school teachers. The high proportion of less qualified teachers (72.80%) highlights a critical challenge in the educational system. However, the lack of significant differences in AI perceptions between qualified and less qualified teachers indicates that formal pedagogical training may not significantly influence attitudes toward AI integration. This finding aligns with Adebayo and Johnson's (2024) [19] research, which suggested that teachers' technological adaptability is more closely related to personal interest and exposure than formal qualifications.

The strong endorsement of AI's potential for personalized learning (Mean=3.57) reflects teachers' recognition of the technology's capacity to address individual student needs. This finding supports Morgan's (2023) [20] assertion that personalized learning represents one of the most promising applications of AI in education. The high rating for interactive and engaging lessons (Mean=3.24) suggests teachers' appreciation of AI's potential to transform traditional biology instruction methods. Teachers' positive perception of AI's role in providing additional learning resources (Mean=3.21) is particularly relevant in the Nigerian context, where resource limitations often constrain educational effectiveness. This finding resonates with Ogunleye's (2024) [21] research highlighting the potential of AI to bridge resource gaps in developing educational contexts.

The primary concern regarding the potential reduction in the need for human teachers (Mean=3.27) reflects broader societal anxieties about AI's impact on employment. However, this concern may be somewhat misaligned with current technological capabilities and educational needs. As noted by Wilson and Chen (2024) [22], AI technologies are more likely to augment rather than replace human teaching roles. The ethical considerations in educational decision-making (Mean=3.13) represent a sophisticated understanding of AI's limitations and potential risks.

This concern aligns with international discussions about AI ethics in education, as documented by the UNESCO report on AI in education (2024) [23]. The consistent perceptions across experience levels suggest that professional development programs for AI integration need not be differentiated based on teaching experience. Instead, as proposed by Kumar et al. (2024) [24], training programs should focus on practical implementation strategies and building confidence in AI utilization. The strong support for AI's collaborative learning potential indicates an opportunity to develop hybrid learning models that combine AI-enabled virtual platforms with traditional classroom instruction. This approach could address both the desire for technological integration and concerns about reduced face-to-face interactions.

5. Conclusion

The results from this research reveal a generally positive attitude toward AI implementation, particularly regarding its potential for personalized learning and interactive instruction. The absence of significant differences across gender, qualification, and experience levels suggests a uniformity in teachers' understanding and acceptance of AI technologies in biology education. While teachers recognize AI's potential to enhance educational delivery and resource accessibility, they express legitimate concerns about its impact on traditional teaching roles and ethical implications. These results show the need for a balanced approach to AI implementation that preserves the essential human elements of education while leveraging technological advantages.

Compliance with ethical standards

Conflict of interest statement

The authors declare no conflicts of interest in the conduct and reporting of this research. No financial or personal relationships existed that could have inappropriately influenced or biased the work.

Statement of ethical approval

This study was conducted with approval from the Department of Science Education, Faculty of Education, University of Ilorin Ethics Committee (Approval Number: 04.08.2024-19/25PA089). The research was carried out in accordance with all relevant institutional and national guidelines and regulations.

Statement of informed consent

Written informed consent was obtained from all participants (biology teachers) prior to their involvement in the study. Participants were informed about the study's purpose, procedures, voluntary nature of participation, and their right to withdraw at any time. All data were collected and processed with appropriate confidentiality measures in place. Permission was also obtained from school administrators before conducting the research in their institutions.

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